Trends and Disparities Among Diabetes-Complicated Births in Minnesota, 1993–2003

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We used Minnesota birth certificate data from 1993–2003 to test 2 hypotheses: rates of diabetes-complicated pregnancy are increasing, and disparities between more and less socially advantaged groups are widening. Significant increases occurred in rates (per 1000 live births) of prepregnancy and gestational diabetes mellitus (from 2.6 to 4.9 and 25.6 to 34.8, respectively). Increases were significant in all demographic groups except gestational diabetes among American Indian mothers, and disparities worsened among all groups. Targeted interventions and surveillance improvements are needed. (*Am J Public Health.* 2008;98:59–62. doi: 10.2105/AJPH.2006.095877)

Prepregnancy diabetes mellitus (PDM), type 1 or type 2, accelerates maternal diabetes complications and increases risk for spontaneous abortions and birth defects.[1] Gestational diabetes mellitus (GDM) can lead to pregnancy-associated hypertension, fetal macrosomia, and cesarean delivery.[2] GDM recurs in up to 70% of subsequent pregnancies, and 17% to 63% of women with GDM will later develop type 2 diabetes.[3] Children of women with GDM face increased risk for obesity and diabetes.[2]

In 1995, 2 in 3 cases of PDM in the United States were type 2.[4] This proportion has likely increased, because obesity and type 2 diabetes prevalence have grown among women of childbearing age.[5] American Indians have the highest diabetes prevalence rates in the United States, and this burden is increasing.[6] Black, Hispanic, and Asian Americans are also disproportionately affected.[7–9]

TABLE 1—Adjusted Relative Risks From Poisson Regression for Increases in Prepregnancy Diabetes Mellitus (PDM)and Gestational Diabetes Mellitus (GDM) Among Singleton Live Births, by Selected Maternal Demographics: Minnesota Residents, 1993 and 2003.

	1993					2003				
		PDM		GDM			PDM		GDM	
	No.[a] (%)	No./1000	RR (95% CI)[b]	No./1000	RR (95% CI)[b]	No.[a] (%)	No./1000	RR (95% CI)[b]	No./1000	RR (95% CI)[b]
Overall	63 037 (100.0)	2.6		25.6		67 634 (100.0)	4.9		34.8	
Age, y										
< 35 (Ref)	55 943 (88.8)	2.4	1.00	22.4	1.00	57 569 (85.1)	4.4	1.00	30.6	1.00
≥ 35	7089 (11.2)	3.8	1.99 (1.52, 2.61)[c]	50.8	2.28 (2.00, 2.59)[c]	10 060 (14.9)	7.8	2.20 (1.68, 2.87)[c]	58.5	1.87 (1.67, 2.09)[c]
Education, y										
< 12	6450 (10.6)	2.0	1.27 (0.84, 1.92)	19.1	0.78 (0.62, 0.97)[c]	7206 (10.8)	6.4	1.51 (1.01, 2.25)[c]	32.9	0.90 (0.74, 1.08)
12	20 296 (33.2)	3.2	2.09 (1.60, 2.73)[c]	27.8	1.21 (1.07, 1.38)[c]	17 335 (26.1)	6.1	1.63 (1.21, 2.19)[c]	36.4	1.15 (1.01, 1.31)[c]
13–15	17 482 (28.6)	2.3	1.48 (1.11, 1.98)[c]	25.6	1.07 (0.93, 1.23)	17 410 (26.2)	5.1	1.41 (1.05, 1.90)[c]	39.2	1.31 (1.16, 1.47)[c]
≥ 16 (Ref)	16 842 (27.6)	2.3	1.00	25.9	1.00	24 501 (36.9)	3.4	1.00	31.2	1.00
Race/ethnicity										
Non-Hispanic White (Ref)	49 566 (89.3)	2.5	1.00	24.5	1.00	51 272 (77.9)	4.1	1.00	31.9	1.00
Non-Hispanic Black	2094 (3.8)	4.3	1.66 (1.10, 2.52)[c]	22.9	0.99 (0.75, 1.31)	5028 (7.6)	6.6	1.59 (1.06, 2.40)[c]	33.6	0.96 (0.78, 1.17)
Asian	1820 (3.3)	2.2	0.64 (0.24, 1.75)	19.2	0.66 (0.43, 1.01)	3699 (5.6)	3.5	1.01 (0.54, 1.91)	54.9	1.36 (1.09, 1.71)[c]
American Indian	753 (1.4)	6.6	3.00 (1.79, 5.04)[c]	39.8	1.70 (1.17, 2.45)[c]	1282 (1.9)	23.4	4.75 (3.14, 7.18)[c]	46.0	1.54 (1.14, 2.09)[c]
Hispanic	1302 (2.3)	1.5	0.77 (0.33, 1.76)	28.4	1.23 (0.87, 1.74)	4499 (6.8)	7.1	1.83 (1.12, 2.97)[c]	49.3	1.40 (1.12, 1.74)[c]
Birthplace										
US born (Ref)	58 774 (93.3)	2.6	1.00	25.3	1.00	56 667 (83.9)	4.8	1.00	31.8	1.00
Foreign born	4201 (6.7)	2.1	0.83 (0.43, 1.60)	29.5	1.32 (0.99, 1.75)	10 865 (16.1)	5.2	0.85 (0.57, 1.28)	50.6	1.41 (1.18, 1.68)[c]
Parity										
Nulliparous (Ref)	24 671 (39.8)	2.8	1.00	23.0	1.00	27 802 (41.3)	4.3	1.00	29.6	1.00
Primiparous	20 595 (33.2)	2.6	0.93 (0.75, 1.16)	26.3	1.07 (0.95, 1.21)	21 599 (32.1)	4.9	1.02 (0.78, 1.32)	34.0	1.10 (0.98, 1.24)
Multiparous	16 790 (27.1)	2.3	0.70 (0.55, 0.90)[c]	28.8	1.08 (0.95, 1.23)	17 904 (26.6)	5.9	1.01 (0.77, 1.32)	44.0	1.27 (1.13, 1.42)[c]

Note. RR = relative risk; CI = confidence interval.
[a]Numbers of births omitted because of missing demographic information (1993, 2003, respectively): age (5, 5); education (1967, 1182); race/ethnicity (7502, 1854); birthplace (62, 102); parity (981, 329).
[b]Adjusted for age, education, race/ethnicity, birthplace, and parity.
[c]$P < .05$.

We used Minnesota birth certificate data to test 2 hypotheses: (1) rates of PDM and GDM are increasing, and (2) disparities between more and less socially advantaged groups are widening.

METHODS

Two checkboxes on Minnesota birth certificates distinguish PDM from GDM as a maternal medical risk factor of pregnancy. We obtained data for all singleton live births to Minnesota residents during 1993–2003 (N=700 761). We categorized a small number of mothers whose records (n=84) indicated unknown diabetes status. We dichotomized maternal age as younger than 35 years and 35 years and older, because finer age groupings within these groups showed little variance in diabetes rates or trends. We defined disparities as differences between groups of mothers more or less advantaged socially by their education, race/ethnicity, or birthplace.[10]

We ran 4 Poisson regression models (PDM and GDM in 1993 and 2003), estimating relative risks adjusted for age, education, race/ethnicity, birthplace, and parity. We tested the significance of trends overall and separately for each demographic group (17 models each for PDM and GDM, for a total of 34) using ordinary least squares regression on log-transformed annual rates. We tested differences in trend slopes (changes in disparities) by including a year × group interaction term in ordinary least squares models (5 each for PDM and GDM, for a total of 10) examining age, education, race/ethnicity, birthplace, and parity. Ordinary least squares models were unadjusted.

Because mothers may have had successive births during the study period, we separately examined births to nulliparous women alone, to assess the bias introduced by this potential source of clustering, and obtained results similar to those reported here. Three alternate methods of handling missing diabetes information (representing

TABLE 2—Percentage Changes Among Singleton Live Births Complicated by Prepregnancy Diabetes Mellitus (PDM) and Gestational Diabetes Mellitus (GDM): Minnesota Residents, 1993–2003.

	Trends in PDM, Estimated Average Annual % Change (95% CI)	Trends in GDM, Estimated Average Annual % Change (95% CI)
Overall	5.9 (4.1, 7.8)[a]	4.4 (2.9, 5.8)[a]
Age, y		
< 35 (Ref)	5.3 (3.4, 7.2)[a]	4.4 (2.9, 5.8)[a]
≥ 35	7.3 (4.5, 10.2)[a]	2.7 (0.9, 4.5)[a]
Education, y		
< 12	10.9 (7.9, 14.1)[a,b]	6.7 (4.3, 9.1)[a,b]
12	6.2 (4.1, 8.4)[a]	3.8 (2.6, 5.0)[a]
13–15	5.6 (2.4, 8.9)[a]	5.2 (4.1, 6.3)[a]
≥ 16 (Ref)	5.9 (2.7, 9.3)[a]	4.0 (1.8, 6.3)[a]
Race/ethnicity		
Non-Hispanic White (Ref)	3.9 (1.9, 5.8)[a]	3.6 (2.2, 5.1)[a]
Non-Hispanic Black	7.8 (1.9, 14.2)[a]	6.1 (3.2, 9.0)[a]
Asian	16.8 (7.7, 26.8)[a,b]	8.2 (5.0, 11.5)[a,b]
American Indian	11.5 (6.3, 16.8)[a,b]	0.8 (−2.7, 4.4)
Hispanic	21.2 (12.2, 30.9)[a,b]	5.6 (3.6, 7.7)[a]
Birthplace		
US born (Ref)	5.2 (3.3, 7.1)[a]	3.5 (2.2, 4.9)[a]
Foreign born	14.7 (9.0, 20.7)[a,b]	6.8 (4.9, 8.7)[a,b]
Parity		
Nulliparous (Ref)	4.5 (2.4, 6.7)[a]	3.9 (2.4, 5.5)[a]
Primiparous	5.0 (2.6, 7.4)[a]	4.3 (2.6, 6.0)[a]
Multiparous	9.3 (7.0, 11.6)[a,b]	5.1 (3.8, 6.4)[a]

Note. CI = confidence interval. Presented are trends and differences in trends between maternal demographic groups observed from ordinary least squares regression.
[a]Significant trend ($P < .05$) within groups.
[b]Significant difference in trends ($P < .05$) between this group and the reference group, tested by including a year × group interaction term in the ordinary least squares model.

6.5% of data collected)—missing omitted from analyses, missing set to "no diabetes," and multiple imputation—produced nearly identical results. Here, we report multiple imputation results from 10 imputations using age, education, race, Hispanic ethnicity, birthplace, marital status, parity, and birth year to predict diabetes status, where missing.[11]

RESULTS

Table 1 presents population numbers, PDM and GDM rates, and adjusted relative risks for the first and last years in our timeframe. Table 2 presents trend results; R^2 ranged from 0.38 to 0.90, with only 10% less than 0.50, indicating acceptable fits for linear trends.

Rates of PDM nearly doubled, and rates of GDM increased 35% over the 11-year period. Increases were significant in all groups, except GDM among American Indian mothers, in whom rates were already high in 1993. Disparities in PDM worsened for mothers with less than a high school education (vs college graduates); Asian, American Indian, and Hispanic mothers (vs non-Hispanic White mothers); and foreign-born mothers (vs US-born mothers). PDM also increased more rapidly among multiparous than among nulliparous mothers. Disparities in GDM widened for mothers with less than a high school education, Asians, and foreign-born mothers (vs same reference groups as PDM).

Over 60% of births to foreign-born mothers were among Hispanics or Asians. Among Hispanic foreign-born mothers, most were from Mexico (83%). Among Asian foreign-born mothers, a majority were from Southeast Asia (Laos, 41.5%; Vietnam, 13.0%; and Thailand, 8.0%).

DISCUSSION

Our results are consistent with several recent reports on diabetes during pregnancy. In the United States, diabetes (GDM and PDM combined) rose by more than two thirds between 1990 and 2004 (from 21.3 to 35.8 per 1000 live births).[12] Previous birth certificate–based studies from regions as diverse as Montana, North Dakota, and New York City have found significant increases in diabetes—GDM, PDM, and the 2 combined.[13,14] Studies of managed care populations from Denver, Colo, and northern California have shown large increases in GDM.[15,16]

Similar to our study, those examining racial and ethnic disparities have shown disproportionate increases among births to American Indian, Black, Asian, and Hispanic women—even though many of these groups, such as American Indians, already suffer high diabetes rates.[13–15] In our study, some of the steepest increases in PDM occurred among Asian and Hispanic mothers, who may face linguistic, economic, or cultural barriers to health care.

Our study has both strengths and limitations. Minnesota birth certificate data are population-based and distinguish PDM from GDM. However, we cannot distinguish type 1 from type 2 diabetes, we lack data on prepregnancy weight, and births to the same mother across years were not linked. Diabetes is underreported on birth certificates by anywhere from 25% to 60%.[17–19] Thus, rates reported here may be interpreted as conservative estimates.

Birth certificate data quality must be improved to effectively guide diabetes interventions. In its 2003 revision, the US standard birth certificate now distinguishes PDM from GDM and includes maternal height and prepregnancy weight.[20] Maternally linked data would be a useful direction for future research.[21]

Diabetes during pregnancy is an opportunity for clinicians and public health professionals, working together, to reduce the burden of this disease. Among those with PDM, a healthy lifestyle and early, aggressive medical therapy can prevent or delay complications.[22–24] Up to one third of women with diabetes have previously had GDM.[25] Type 2 diabetes can be cost-effectively prevented or delayed among those at high risk, including women with GDM history, through behavioral and pharmacological interventions.[26,27]

Health system registries can guide testing and follow-up. Pregnancy is a "teachable moment," but healthy lifestyle changes are difficult to maintain.[28] Interventions must address challenges faced by mothers of young children, such as fatigue, limited time for exercise or food preparation, and possible feelings of depression and social isolation, especially for poor women.[29] For new immigrants, barriers may also include acculturation stress and lack of community support.[30] Targeted interventions could provide high leverage to reduce the diabetes burden. ■

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Contributors

H.M. Devlin conceptualized the study design, conducted analyses, and led the writing. J. Desai conceptualized the study design and provided input on the public health implications. G.S. Holzman provided clinical expertise and references. D.T. Gilbertson provided statistical expertise and conducted analyses.

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Human Participant Protection

Protocol approval was not necessary for this study because all information was derived from pre-existing and publicly accessible birth certificate data.

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